December 1940

ACE-71
(RSLM-3)

PROCESSING SOYBEANS FOR OIL AND MEAL

Soybeans vary considerably in color, size, and chemical composition. Variety, climate, and type and fertility of the soil on which they are grown affect the chemical composition of the bean. On a moisture-free basis, the oil content ranges from 14 to 24 percent with an average of 19.8, the protein content from 30 to 50 percent with an average of 42.9, and the ash from 3.5 to 6 percent. Only the varieties with yellow seed coats are processed on a large scale.

According to the United States standards which have been established for soybeans, the No. 2 grade must meet the following requirements: The beans shall be cool, of natural color, and may be slightly stained or mottled; they shall have a minimum test weight of 54 pounds per Winchester bushel; and maximum limits of 15 percent moisture, 10 percent splits, 3 percent damage, 2 percent foreign material, and 3 percent other colors. Soybeans are usually sold on the basis of the legal bushel which is defined as weighing 60 pounds. Information concerning grading service for soybeans may be obtained from the Bureau of Agricultural Economics, U. S. Department of Agriculture, Washington, D. C.

A futures market for soybeans is provided on the Chicago Board of Trade, for soybean oil meal on the Memphis Merchants Exchange, and for soybean oil on the New York Produce Exchange.

Soybeans are shipped and stored in much the same manner as corn, wheat, and other grains. Clean, cool beans free from soil and mold may be stored safely for protracted periods provided the moisture content does not exceed 13 percent. If, however, there is evidence of heating or if the beans are moldy or excessively dirty, extensive damage may result on storing even if the moisture content is considerably under 13 percent.

Hydraulic pressing, expeller or screw pressing, and solvent extraction are the three methods in general use for extracting oil from soybeans. All find application in this country. The 1939 crop yielded about 90 million bushels of beans of which approximately 60 million were processed for oil and meal. Roughly three-fourths of the beans were processed by means of continuous presses (expellers or screw presses), one-sixth to one-fifth by solvent extraction, and the remainder by hydraulic pressing. At present there are approximately 90 soybean processing mills in the United States.

Hydraulic pressing of soybeans is used almost exclusively by those plants which also process or have processed other oleaginous seeds. Cottonseed and linseed pressing mills have been adapted satisfactorily to soybeans by modifying the milling and cooking equipment and the procedure. The beans are ground, rolled into thin flakes, cooked, formed

into cakes which are wrapped with hair or wool mats, and pressed. The cakes are then trimmed, ground, and bagged. Under favorable conditions the cake as it comes from the press contains about 5 percent oil.

When continuous presses are used, the beans are rather coarsely cracked, dried to a moisture content of 2 to 3 percent, and conveyed to a temperer mounted above the expeller where they are heated and the moisture content adjusted to a value which yields the best results under the pressing conditions employed. The hot, cracked beans are fed continuously into the expeller or screw press where they are compressed by means of a powerful rotating screw and forced through a cylinder which is composed of longitudinal steel bars spaced a few thousandths of an inch apart. The high temperature employed and the pressure developed in the process cause the oil to be squeezed out of the beans, and it escapes from the compressed material by flowing out through the slots between the bars. The material remaining is forced on through the cylinder and is discharged as irregularly shaped fragments containing 4.0 to 5.5 percent oil. It is cooled and ground to produce soybean oil meal. The crude oil is screened and then clarified by filtration before being sent to the refinery.

One ton of soybeans processed by either the hydraulic or expeller press yields approximately 300 pounds of oil and 1,700 pounds of cake. Continuous pressing is favored over hydraulic crushing because less hand labor is required. Subsequent treatment of the oil to obtain the grades offered to the various industries is essentially the same in both pressing processes.

In the solvent extraction of the oil as carried out in this country, the soybeans are cracked and adjusted to a moisture content of about 12 percent. They are then rolled into thin flakes and passed continuously through an extractor countercurrent to the flow of solvent which is usually a commercial grade of hexane. After the extracted flakes are discharged, they are freed from the entrained solvent which is returned to the system. When the product is used as a source of industrial protein, this solvent removal should be effected with a minimum application of heat and in the absence of moisture in order to avoid denaturing the protein. On the other hand, high temperatures are used to evaporate solvent from flakes which are destined for use in feeds, and the solvent-free meal is further toasted, i.e., heated to a high temperature in the presence of considerable moisture, in order to impart to it a golden brown color, agreeable taste and odor, and enhanced nutritive value. When the extraction process is operated efficiently, the meal contains essentially no solvent and 1 percent or less oil. The solvent is distilled from the oil and is returned to the extractor. With a proper installation and good supervision solvent losses should be kept under 0.75 percent of the weight of the beans extracted. The solvent extraction process is used widely in Europe, and is slowly but steadily entering the soybean industry in this country.

The meal produced in processing soybeans is of interest chiefly because of its protein content. Little attention has as yet been paid to its carbohydrate fraction which is distinguished by its very low content or complete absence of starch. The protein apparently consists largely of the globulin, glycinin, together with smaller quantities of albumin-like legumelin. The principal amino acids found in glycinin, together with their approximate percentages, are as follows: Glutamic acid, 20 percent; aspartic acid, 9 percent; lysine, 9 percent; leucine, 9 percent; arginine, 8 percent; phenylalanine, 4 percent; and proline, 4 percent. Other identified amino acids are present in smaller quantities. Soybean meal finds its greatest use as a protein concentrate for the feeding of livestock, and although no official estimates are available, probably over 95 percent of the soybean meal annually disappearing in trade is so utilized. It is being used in the food industries to an increasing extent where various applications are being developed. The industrial utilization of soybean meal and protein is based primarily on their adhesive properties, with the plywood and wallpaper coating industries using the largest quantities. Soybean meal is also used in plastics, orchard sprays, and foundry core binders, and the protein is finding application in beater and tub sizing of paper, sizing for silk hosiery, water paints, and leather dressings.

Soybean oil is a mixture of fatty acid glycerides and is classed as a semi-drying oil with an iodine number ranging from 120 to 141. The fatty acid content of a typical soybean oil is: Saturated, 15.2; oleic, 23.6; linoleic, 57.9; and linolenic 3.3 percent. The saturated acids are approximately two-thirds palmitic and one-third stearic. Other fatty acids are present in small amounts. The refined oil is utilized chiefly in edible products, such as vegetable shortenings, salad and cooking oils, and margarine. The crude oil is refined by suitable alkali treatment and bleached with activated carbon or earth. The oil is then deodorized by being heated in a high vacuum while a current of steam is passed through it. The oil is also used in the manufacture of paints, enamels, varnishes, linoleum, oilcloth, soap, and printing inks. Special grades of oil refined by suitable methods for specific uses are produced by the larger refiners of soybean oil. Information concerning trading standards for soybean oil may be obtained from the National Soybean Processors Association, 3818 Board of Trade Building, Chicago, Illinois.

Phosphatides, composed chiefly of lecithins and cephalins, occur in soybeans and are found in quantities ranging from 0.4 to 2 percent in both solvent- and pressure-extracted oils. At present phosphatides are recovered chiefly from solvent-extracted oil by emulsifying them with water and oil and separating the emulsion from the oil in a centrifuge. The phosphatides thus obtained are dried at low temperatures and pressures to a brown mass, and contain approximately 40 percent oil and less than 1 percent moisture. Soybean phosphatides find use as wetting agents and antioxidants, principally in the confectionery and food industries. When properly purified, commercial soybean phosphatides are of a light brown color and are almost completely free from pronounced beany odor. Should wide uses develop for soybean phosphatides, they could also be obtained directly from the bean as well as from the expressed oil.

A large number of the growers of soybeans, and others interested in the industry, are associated in the American Soybean Association, J. B. Edmondson, Secretary-Treasurer, Clayton, Indiana.

No attempt will be made to furnish cost data for the installation and operation of different types of milling and processing equipment since these data together with considerable related information may be obtained from manufacturers of such equipment. In listing the names of the following companies it is to be understood that their products are not recommended over those of any others engaged in the same line of business, but their names are furnished merely for the convenience and information of those interested.

Manufacturers of Soybean Processing Equipment

Continuous presses:

V. D. Anderson Company, Cleveland, Ohio
French Oil Mill Machinery Company, Piqua, Ohio

Hydraulic pressing equipment:

French Oil Mill Machinery Company, Piqua, Ohio
Davidson-Kennedy Company, Atlanta, Georgia
Buckeye Iron and Brass Works, Dayton, Ohio

Continuous countercurrent solvent extractors:

Vulcan Copper and Supply Company, Cincinnati, Ohio
French Oil Mill Machinery Company, Piqua, Ohio
Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin
Albert H. Bruecke (Bollmann system), 10 Carlisle Street, Bergenfield, New Jersey
Sieck and Drucker, Inc. (Hildebrandt system), 9 South Clinton Street, Chicago, Illinois
Detroit Rex Products Company, 13005 Hillview Avenue, Detroit, Michigan

Milling equipment:

Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin
B. F. Gump Company, 441 South Clinton Street, Chicago, Illinois

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18. Swift's New Soy Bean Plant at Fostoria, Ohio. Grain and Feed Journals Consol., 85, 281, 302 (1940).

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21. The Composition and Nutritive Properties of Soybeans and Soybean Oil Meal. Soybean Nutritional Research Council, 3818 Board of Trade Building, Chicago, Illinois.

22. Expeller Extracted Soybean Oil Meal. J. W. Hayward. Grain and Feed Journals Consol., 77, 215 (1936).

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(Compiled by the U. S. Regional Soybean Industrial Products Laboratory, Urbana, Illinois, a cooperative organization participated in by the Bureaus of Agricultural Chemistry and Engineering and Plant Industry of the U. S. Department of Agriculture, and the Agricultural Experiment Stations of the North Central States of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.)